rough texture indirectly if the upper electrode **32***a* disposed above the notches **34** and a film (not shown) disposed on the upper electrode **32** to directly contact the user are made using a flexible material.

[0060] A crack in each of the notches **34** becomes larger, increasing a rough texture, as the protrusion of the electro-active polymer **31** increases, that is, as the voltage applied to the two electrodes **32***a* and **32***b* increases. Accordingly, the texture of the haptic button **110** can be controlled by controlling the voltage applied to the two electrodes **32***a* and **32***b*.

[0061] FIGS. **6**A and **6**B illustrate the basic concept of haptic buttons according to a third exemplary embodiment of the present invention, in which FIG. **6**A illustrates a haptic button **120** further including a single separator **35** as compared to the haptic button **100** and FIG. **6**B illustrates a haptic button **130** further including two separators **35***a* and **35***b*. The separators **35**, **35***a*, and **35***b* suppress the horizontal expansion of an electro-active polymer but allow the electro-active polymer to move up and down according to a pressure applied by a user.

[0062] Two electro-active polymers **31***a* and **31***b* separated by the separator **35** illustrated in FIG. **6**A and three electro-active polymers **31***a*, **31***b*, and **31***c* separated by the separators **35***a* and **35***b* illustrated in FIG. **6**B may be separately controlled using electrodes separately driving the electro-active polymers **31***a*, **31***b*, and **31***c*. Accordingly, the electro-active polymers **31***a*, **31***b*, and **31***c* may have different heights of protrusion and only some of the electro-active polymers **31***a*, **31***b*, and **31***c* may be activated.

[0063] FIG. **7** illustrates the appearance of a portable device **200** including the haptic button **100**, **110**, **120**, or **130**. All of buttons included in the portable device **200** or only some of them may be the haptic button **100**, **110**, **120**, or **130**. The buttons included in the portable device **200** are defined by a face plate **60**.

[0064] FIGS. **8**A, **8**B, **8**D, and **8**F are cross sectional views of the haptic buttons **100**, **110**, **120**, or **130** illustrated in FIG. **7**, taken along the line a-a'. FIGS. **8**A through **8**C are diagrams for explaining the detailed structure of the haptic button **100** according to the first exemplary embodiment of the present invention.

[0065] Referring to FIG. **8**A, the haptic button **100** may include a key top **51** physically contacting a user, a rubber cover **54** disposed blow the key top **51**, the electro-active polymer **31** disposed below the rubber cover **54**, the two electrodes **32***a* and **32***b* respectively disposed at both sides of the electro-active polymer **31**, a metal dome **55** disposed below the electro-active polymer **31** to provide a clicking feeling when the user presses the haptic button **100**, and upper contacts **58** and a lower contact **59**, which are disposed below the metal dome **55** and contact each other when the haptic button **100** is pressed.

[0066] In addition, a position of the metal dome **55** is fixed by a plate **56**. The fixing portion **33** is disposed between the electro-active polymer **31** and the plate **56** to secure a space for the metal dome **55**. As described above, the fixing portion **33** also fixes the electro-active polymer **31** so that the horizontal motion of the electro-active polymer **31** is suppressed. In addition, a spacer **53** is disposed between a flexible film **57**, to which the upper contacts **58** are attached, and a lower case **52**, to which the lower contact **59** is attached, to separate the upper contacts **58** from the lower contact **59**. The haptic button **100** is defined by the face plate **60**.

[0067] The electro-active polymer **31** may be spread throughout an area including a plurality of haptic buttons **100**, but the two electrodes **32***a* and **32***b* are provided for each of the haptic buttons **100**. Accordingly, when a voltage is applied to the two electrodes **32***a* and **32***b* included in a particular haptic button **100**, only the particular haptic button can be activated.

[0068] FIG. **8**B illustrates a state of the haptic button **100** illustrated in FIG. **8**A when a voltage is applied to the two electrodes **32***a* and **32***b*. When a voltage is applied to the two electrodes **32***a* and **32***b*, the electro-active polymer **31** is expanded and protrudes upward and provides repulsive power to a user pressing the haptic button **100** according to a level of the voltage. The metal dome **55** illustrated in FIGS. **8**A and **8**B has a predetermined stiffness. An artificial stiffness of the electro-active polymer **31** is added to the predetermined stiffness of the metal dome **55** so that overall stiffness appropriate to a current status can be provided to the user.

[0069] FIG. **8**C is a graph of displacement generated when a user presses the haptic button **100** versus force (or pressure) provided to the user. A curve (A) is a force-displacement graph of the metal dome **55** and a curve (B) is a force-displacement graph obtained when the electro-active polymer **31** is activated. When the stiffness of the metal dome **55** is referred to as a bias stiffness, overall stiffness can be variously changed by adjusting a stiffness added by the electro-active polymer **31**.

[0070] Referring to FIGS. **8**A and **8**B, the metal dome **55** is used to provide the bias stiffness. However, various levels of stiffness can be provided to a user by using only the electro-active polymer **31** without using the metal dome **55**. FIG. **8**D illustrates a haptic button **105** providing stiffness using only the electro-active polymer **31**.

[0071] In the haptic button **105**, the plate **56** and the flexible film **57** are disposed below the electro-active polymer **31**. When a voltage is applied to the two electrodes **32***a* and **32***b*, the electro-active polymer **31** protrudes upward. Here, if the voltage is applied in various waveforms, the haptic button **105** can provide a user with various stimulations such as vibration and impact. In addition, the strength of stimulation can be controlled by controlling a level of the voltage.

[0072] FIG. **8**E illustrates various stimulations that can be provided by the haptic button **105**. The strength of stimulation can be controlled by a voltage applied to the two electrodes **32***a* and **32***b*. The voltage changes according to displacement generated when a user presses the haptic button **105** or a period of time during which the user presses down the haptic button **105**.

[0073] In FIG. **8**E, a curve (A) shows a voltage waveform for providing stimulation linearly increasing according to displacement, a curve (B) shows a voltage waveform for providing impact stimulation, a curve (C) shows a voltage waveform for providing stimulation rapidly increasing according to the displacement, and a curve (D) shows a voltage waveform for providing stimulation similar to that provided by the metal dome **55**. Besides, many other stimulations can be provided to a user by changing the waveform of the applied voltage.